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Hawaii Agricultural Experiment Station, HONOLULU.

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PRESS BULLETIN NO. 34

COTTON IN HAWAII.

BY

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AND

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The recent attempt at reviving the cotton industry of Hawaii has met with only partial success. There are many reasons why this crop has not been more extensively grown, some of which will be discussed in this report. The profitableness of the sugar industry, the greater hardiness and wind-resisting qualities of rice, sugar cane and pineapples as compared with cotton, their lesser susceptibility to attacks from insects, and perhaps the traditions of the Chinese, which hold them to the production of rice, are some of the factors which have retarded cotton culture in places where the above crops could be grown, while in other places not suitable for these crops, where water was insufficient for rice or sugar cane or soil conditions were unsuitable for pineapples, cotton has been tried and in some cases given up, because the location was unfavorable or because the crop was so badly infested with insects as to be unprofitable, and in some instances both of these conditions caused the abandonment of the crop.

On the other hand the crop in some instances under some con-

ditions has been such as to justify its continuation. The aim of the present report is to inquire into these conditions and give such information as will help the new grower, as well as results which will be of interest to those already engaged in growing cotton.

ENVIRONMENT.

A favorable environment for cotton must be secured. The most important feature of a favorable environment is location.

LOCATION.

Cotton is a heat-loving plant and can be profitably grown only in protected places, where it is not too cold, where there is little or no wind, or where nights are not too cold. Some locations that have been tried preclude any possible chance of profit. In the cotton-growing regions of the South, it will be recalled that the average daily temperature in summer is higher than in Hawaii and in Hawaii cotton culture should be attempted only where temperature conditions approach those found in the South. High elevations are likely to have wrong conditions. However, at 2,000 feet elevation in Kona, Hawaii, where there is virtually no wind, we have received as good staple as we have grown on Oahu under 300 feet, yet there can be no doubt in our minds that, with other conditions equal, cotton will be *more productive* at the lower elevations. In fact the highest yields reported have always been from near sea level. The station has made some experiments at Waipahu, 700 feet elevation, and at Kunia; and other trials have been made in Waipio, about 650 feet elevation, near Wahiawa, and these trials prove without doubt that in such exposed locations cotton will not produce nearly as well as in more protected places. Upon windward Oahu at sea-level, the wind there being warm and steady, better results were obtained than at the above mentioned places, where the wind was colder and broken up into gusts by uneven mountain peaks and gulches. Upon the Experiment Station grounds during windy times it has often been noticed that cotton bolls would be produced only upon the leeward side of the plants, on plants that were particularly exposed. With Sea Island cotton in a protected place in 1910 individual plants yielded about one pound of seed cotton. Seed was taken from selected plants of this plat

and planted upon slightly higher and more exposed land, and in 1911 this planting yielded less than two-thirds of a pound of seed cotton to the plant, which affords evidence of the lessened yield under more exposed conditions.

MOISTURE.

Under Hawaiian conditions all cottons are, or tend to become, perennial, and as perennials they have a tendency towards continual growth, accompanied by a continual production of flowers and bolls where the supply of moisture is optimum at all times. In sections where rainy seasons and dry seasons alternate, the usual habit is to make a heavy vegetative growth during the rainy season and produce the crop in the dry season when the vegetative growth is checked. The continued moderate supply of moisture by rainfall or irrigation, with its consequent continual fruiting of the plant, work against economical production of the cotton, in that repeated pickings,* which are costly, are required, yet the total annual production might be greater where such conditions exist.

Where the rainfall is excessive and continuous the cotton plant will produce but little and will make an excessive vegetative growth. The Caravonica variety in particular under such conditions has a tree-forming tendency.

Another apparent influence of moisture was noticed upon our Sea Island cotton. During the dry weather in 1911 the soil became checked with deep, wide cracks. When the first picking was made in the last of August, and to some extent also in the second picking in September, the individual locks were not open or flushed and the lint was a trifle shorter than it should have been. After a few good rains the third picking was taken off in October and was greatly improved in these particulars. Further observation will be necessary to confirm these conclusions, since the better state of the cotton may have been due to other causes.

*Under conditions at Makaweli, Kauai, a crop was picked and the plants dormant by the first week of August, while at the Experiment Station where occasionally rains were had, the pickings were continued into October while the largest pickings of the year, as will be seen from table I, were obtained on September 8th and September 16th. The variety in both cases was Caravonica.

SOILS.

The character of the soil upon which to grow cotton seems to be of much less importance than the other factors already mentioned. Cotton is now being successfully grown upon all types of soil, from the heaviest clay to the lightest sands along the coast. Provided that the soil has moisture and a fair degree of fertility cotton can be grown. Even where the soil moisture is too brackish for other crops up to a certain limit, cotton will thrive.

VARIETIES.

Of the different varieties of cotton which have been tried at the Experiment Station, only the Caravonica and Sea Island varieties have been tested sufficiently to justify the publication of any results.

CARAVONICA.

This variety was originated in Australia, but seems to be one of the better varieties under Hawaiian conditions. It is of hybrid origin and the variety is open to criticism in many particulars, but the greatest objection to it is its variability. The majority of the plants are upright in their habit of growth, but many prostrate forms may be found. Some plants are very prolific, producing 500 to 1,000 bolls, while adjoining plants with equal chance may produce less than 50. Some seeds are tufted, some smooth, some more or less fuzzy and some are held together as in "kidney" cotton. The fiber varies from one to one and five-eighths inches in length. It may be very rough or it may be equally smooth, and the percentage of lint may vary from 28 to 44 per cent.

The soil should be well prepared for Caravonica and there should be a reasonable amount of moisture in the soil before planting. Usually early spring is the better time at which to plant, but the occurrence of rains (or supply of water where the moisture is under control) may better determine the planting season. Under dry conditions a good irrigation before planting would be advisable, in order to hasten germination and get the plants well started. This variety has been thought to be shy in bearing in its first year and it usually is, but when it has a proper degree of heat and plenty of moisture while young it will pro-



Seeds of Caravonica are usually smooth with tuft at one end; the bracts are large; the bolls, usually three locked and opening widely allowing cotton to fall out.

duce well for the first season, although the plants will not uniformly do this. One plant at our rice trial grounds, King street and Kalakaua avenue, from seed planted in March, 1911, yielded four pounds of seed cotton within nine months. This, of course, is exceptional and shows the possibilities of the first year, from seed of good stock, and under best conditions of heat and moisture.

The distances at which to plant this variety will vary with the conditions under which it is to be grown and which determine the size of the plant. Eight by seven, eight by eight, and nine by seven are the usual distances, but in some locations as much as ten feet between rows may be advisable. To secure a stand, plant several seeds in a hill, and where cutworms are found, encircle the hills with a sprinkling of poisoned bran. Later on the hills should be thinned to a single plant. Cultivation should be given at such times as will keep the ground free from all weeds and conserve the moisture. Early cultivation will induce a deep rooting of the plant, and irrigation at this stage is inadvisable. The cost of cultivation will in the end largely determine whether or not the crop will be a success, and it is hardly to be expected that rough and rocky places, where handwork alone is possible, will yield any profit in producing cotton.

During the first year it is possible to grow some other crop between the rows. Cow peas, peanuts, garden peas, soy beans, watermelons, potatoes and other crops have been grown, but it is advisable to grow only short-season crops, so that the ground will not be occupied for any length of time.

PICKING.

When the bolls commence to open frequent pickings are necessary. The bolls open wide and the locks flush out, and there is no cotton exhibiting a more beautiful appearance than Caravonica when showing a considerable number of open bolls. However, if the bolls are allowed to remain too long after opening, rain, winds, birds and gravity get in their work and the cotton will soon be upon the ground. In regions of no wind or storms of any kind it may be possible to have three or four weeks between pickings, but ordinarily eight to fourteen days between

is all that should be allowed. Where clean culture for the control of boll worm is practiced, better results will no doubt be obtained by the more frequent pickings. In 1911, under our conditions, the average interval between pickings was about eight days. The amount which can be picked in a day depends upon the amount of cotton open, which in turn depends upon the season of the year, the length of time elapsed since last picking and the prolificacy of the plants. In other words, the amount picked depends upon the amount of surface, both of ground and plant, which the picker must cover in a given time. A willing, experienced and active picker of course has an advantage over those less willing and the slow and awkward. Another feature that must not be overlooked is the amount of moisture at picking time. Pickers often insist on picking when the cotton is damp so as to increase their weights, but only dry seed cotton should be paid for. The largest amount reported for one picking was 125 pounds, but in this case there was admitted to be 50 per cent moisture present. Seventy-five pounds of dry seed cotton will be found to be a high average daily picking for labor here obtainable. With more experienced help and more energetic help this figure should be exceeded. One dollar per hundred pounds is the minimum wage paid, but the average price for dry seed cotton has averaged above \$1.50. Unless perfectly dry when picked, the cotton should be well dried before storing in bulk; otherwise it may be injured.

Caravonica cotton is used largely in mixed woolen goods, where long, rough, strong fiber is required. The length, as given above, varies from 1 to $1\frac{3}{8}$ inches. The average breaking strength as given by the Department at Washington is nearly 9 grams, while that of short staple Upland cotton is about 7 grams and of long staple Upland cotton between 4 and 5 grams. Because of this greater strength many think the Caravonica could be ginned without injury upon the saw gin. We have submitted sample bales of both roller and saw ginned cotton to an Eastern firm for examination and report. With a two horsepower gasoline engine, a small 14-inch roller gin, at 120 revolutions per minute, had a capacity of about 14 pounds of lint per hour. With hand power, at 45 revolutions per minute, the gin has a capacity of only about 7 or 8 pounds per hour. With same engine a saw gin with ten 12-inch saws, at 250 revolutions per

minute, ginned 40 to 50 pounds of lint per hour. This shows the relative capacity of these two gins. However, the percentage of lint obtained from the roller gin varied from 1 to 2 per cent higher than cotton from the same lot when ginned upon the saw gin. Thus, while the saw gin has a much larger capacity, there results a loss (in a 40% cotton) of $2\frac{1}{2}$ to 5 per cent of the fiber when ginned upon a saw gin. It should be kept in mind that for long staple cottons saw gins should be run slower than for short staple cottons, or at a less speed than usually recommended in gin catalogues. The gasoline to run this engine cost about 4 cents per hour. When the cost of operation by gas power is compared with the cost of hand labor, and when it is known that even two men cannot keep the gin running steadily, it will be seen that power ginning is much cheaper than hand ginning, and it will probably pay the small grower to hire ginning done rather than to use hand power machines.

BALING.

There is no uniform size or shape to be found among the bales in Hawaii. Round bales and rectangular bales, both from manufactured and home-made presses are to be found. For round bales, sacks made of wool pack, $3\frac{1}{2}$ feet in diameter and 7 or more feet long, are used. For square or rectangular bales, a poorer quality of bagging can be used, with ropes or wire ties. From 300 to 500 pounds should be put in a bale, and the bale should be protected from the weather.

TABLE No. 1
.72 Acres

1911 Record of 306 Caravonica Plants				Early Pruned, Cut Back December 5, 1910					
No of Picking	Date of Picking	Infest- ed Bolls	Good Bolls	Seed- cotton Pounds	Lint Lbs.	Seed Lbs.	Per Cent Lint	Bolls per lb. seed- cotton	Per cent Infested
Prelimi- nary	May 24	45	.45	.16	.29	37.5	99
1	" 31	318	132	1.38	.51	.87	37.5	94	70.6
2	June 9	409	418	5.47	2.08	3.39	38	75	49.5
3	" 17	378	1075	13.5	5.01	8.49	37.1	78	26
4	" 24	652	973	14.45	5.74	8.71	39.7	67	39.9
5	July 5	665	3788	39.35	15.71	23.64	39.9	96	14.9
6	" 12	590	5382	60.4	28.8	36.6	39.6	89	9.8
7	" 20	727	5790	65.55	24.79	40.76	37.8	88	11.1
8	" 26	534	6767	75.61	28.60	47.01	37.8	89	7.3
9	Aug. 2	616	5856	58.88	22.76	36.12	38.6	99	9.5
10	" 11	121	3707	41.2	16.48	24.72	40	89	3.1
11	" 17	178	4041	44.53	17.43	27.10	39.1	91	4.2
12	" 26	686	6712	73.22	29.08	44.14	39.7	91	9.2
13	" 31	399	7469	78.64	31.71	46.93	40.3	94	5
14	Sept. 8-9	594	9158	94.86	39.25	55.61	41.3	96	6
15	" 16	322	10813	112.37	45.87	66.5	40.8	96	2.9
16	" 22	140	4994	53.62	22.81	30.81	42.5	92	2
17	" 29	302	5588	50.25	20.50	29.75	40.7	111	5.1
18	Oct. 10	119	2627	27.43	11.62	15.81	42.3	95	4.3
19	" 20	67	1260	10.48	4.33	6.15	41.3	120	5
Final	Nov. 10	283	2228	17.25	6.5	10.75	37.6	112	2.7
TOTAL		8100	88823	938.89	374.74	564.15	Av 39.9	Av. 95	Av 8.3
From unnumbered plants					8 06				
TOTAL					382.8	or 531 lbs. per acre.			

Caravonica fiber sells upon the market at prices varying from 15 to 25 cents per pound, depending upon the year, the demand and supply, and the length, quality and cleanliness of the cotton. The yields per acre upon the Station grounds from one-year-old trees which had been pruned in December, 1910, was at a rate

of 531 pounds of lint per acre. Upon similar trees pruned in March, 1911, the yield was only at the rate of 363 pounds per acre, the average yield upon the field being 448 pounds per acre, which is approximately four times the yield that was obtained from the same field in 1910. The Kaneohe Cotton Company reported an average of less than 400 pounds lint per acre from plants in their second year from an area of 13 acres, but a large percentage of their crop was lost through bollworm and also by a fungous disease of some kind. Under better conditions near Pearl City, much heavier yields have been secured, and a report of this planting will be given in another place. Tables I and II give yields by pickings, with the percentages of lint and of worm infestation, and showing the number of bolls per pound at different pickings.

TABLE No. II
.70 Acres
Late Pruned March 1-4, 1911.
Spring Crop

No. of Pickings	Date of Picking	Infested Bolls	Good Bolls	Seed- cotton Pounds	Lint Lbs.	Seed Lbs.	Per Cent Lint	Bolls per lb. Seed- cotton	Per Cent Infested	Length of Lint in 16th of an Inch
1-4	Jan. & Feb.	2307	13241	108.	39	69	Av 36.1	Av 122	Av 19.5	

Fall Crop

1	Aug. 11	52	1420	16.96	8.51	10.45	38.3	83	3.5	
2	" 17	43	1181	13.78	5.31	8.47	38.5	84	3.5	20
3	" 26	84	2128	25.06	9.75	15.31	38.9	84	3.7	
4	Sept. 1	174	4320	43.52	17.08	26.44	39.2	100	3.8	21
5	" 9	257	9778	100.50	40.75	59.75	40.5	97	2.6	
6	" 17	243	10946	114.75	45.85	69	39.8	95	2.1	22
7	" 23	215	4181	39.75	15.25	24.50	38.8	104	4.9	
8	" 30	295	10316	92	36	56	39.1	112	2.7	22
9	Oct. 10	82	4637	40.62	15.12	25.50	37.4	113	1.7	
10	" 20	160	2270	20.28	8.44	11.84	41.5	110	6.5	21
Final	Nov. 10	234	2143	20	7.25	12.75	36.2	107	9.8	23
Total Fall crop		1839	53320	527.22	207.21	320.01	Av 39.3	Av 101	3.3	
Total Spring and Fall crop		5046	66561	635.22	246.21	389.01	" 38.7	" 104	7	
From unnumbered plants					8.06					
Total					254.27	or 363 lbs. per acre				

PRUNING.

When pruning back the plants, clean cuts should be made with saw or shears. Pruning is practised to aid in worm control, as previously stated in Press Bulletin No. 32, but even without worm conditions it would be necessary in order to control the size and shape of the plant; otherwise the expense of picking would in time be prohibitive. It is necessary, also, to maintain the quality of the fiber, since this usually deteriorates in neglected plants. For how many years it will be possible to renew the plants has not yet been determined. Whether to prune high or low, or when to do one in preference to the other is also yet unknown, other than the general rule that the shorter the time that is to elapse before a good fruiting season, the higher the pruning should be made. Table III gives results from two plats pruned at 2 and 4 feet, respectively. This pruning was done in December in the rainy season, and one method was practically as efficient as the other. The figures have been given showing the comparative yields from the early and late prunings made here. An experiment in light pruning or pinching back the new branches at different times during the growing season was tried, but the greatest benefit came from restricting the height of the plant. It was thought that pinching back would induce the growth of fruiting branches and increase yield while at the same time restricting vegetative growth, but Table III shows that no great difference in the yield resulted.

TABLE No. III
Results of Pruning Experiments. Caravonica "Wool."

Pruned high and pinched back at time of	Infested Bolls	Good Bolls	Seed-cotton pounds	Lint Lbs.	Seed Lbs.	Per cent Lint	Bolls per lb.	Per cent Infested	No. of Plants
Squaring	1769	14597	159.4	64.08	95.32	40.3	91	10.8	52
Flowering	1282	14459	151.73	60.23	91.5	39.6	94	8.1	51
Check	1731	14513	160.09	63.85	96.24	39.8	89	10.6	48
Total	4782	43569	471.22	188.16	283.06	39.9	91	9.6	

Low pruned and pinched back at time of

Squaring	920	13898	150.24	60.19	90.05	40.	91	6.2	51
Flowering	869	13354	141.65	56.58	85.07	39.9	92	6.9	51
Check	1117	15004	156.16	62.17	92.99	39.8	96	6.9	53
Total	2906	42256	448.05	178.94	269.11	39.8	92	6.4	306

The cost of pruning, as reported from different growers, has varied from \$2.50 to \$5.00 per acre, while upon our own planting it amounted to about \$5.70 per acre. The cost will depend largely upon the rankness of growth of plants and somewhat upon the height of pruning, since when pruning high more cuts per tree will be required. To remove pruned branches from the field one man has devised a sled with a rack, which is drawn between the rows by a mule, and the pruned branches are placed thereon at the time of pruning and hauled at once to the sides of the field where they can be burned.

SEMI-ANNUAL PRUNING—TWO CROPS PER ANNUM.

This is a practice that is possible only where the very best environment is present and where some conditions are under control. Mr. E. C. Smith, a pioneer cotton experimenter of Pearl City, Oahu, has succeeded in producing two crops per year for the past two seasons. (Mr. Smith was also the first to practice and advise budding of Caravonica so as to secure better uniformity.) His method is to pick off a crop in June and July and immediately prune back the plants and give enough irriga-

tion to start a new growth. This new growth under his conditions makes a crop in December and January, when another pruning is made, resulting in another crop in June and July. To secure this result he has conditions as follows:

- (a) Elevation not over ten feet.
- (b) Perfect protection from wind, secured by surrounding fringe of algeroba trees.
- (c) Few cloudy days, so that full benefit of sun's rays is received.
- (d) Possibly some slight benefit of deep sub-irrigation, but surface soil is generally excessively dry.
- (e) A small area.
- (f) Water to start new growth in July or August or in February if rains fail to come.

Upon three-year-old plants pruned in July of 1910 a winter crop of 2.5 pounds per tree was obtained, while in the following July 4.7 pounds were picked, making a total of over 7 pounds seed cotton per tree for the year. All cotton opening upon pruned branches within two weeks after pruning is included.* This plat consisted of forty trees, planted 8x7 feet, or at a rate of 778 plants per acre, and the yield was at an annual rate of more than 2,000 pounds lint per acre. No doubt these plants can exceed this record, since their productiveness to date has increased with their age.

However, because of worm infestation—largely from neighboring neglected fields—the winter crop for 1911-1912, although promising good returns, was practically a failure, and the plants were pruned back in December in order to destroy the worm and no winter record is obtainable.

This two-crop method is certainly worthy of more complete trial and should be tested by growers who have similar conditions. One thing is certain: that where anyone can follow this practice, and provided his neighbors do likewise, the worm can be controlled at nominal expense and the crop assured.

*Cotton opening on branches after pruning shows deterioration. The longer the time elapsing before the opening of the bolls, the greater the deterioration. Only that which is fully open within about ten days is worth saving—at least for spinning purposes.



A result of semi-annual pruning—field of E. C. Smith, Pearl City,
July 1st, 1911.
24 lbs. seed cotton were picked from each plant at this time.

SEA ISLAND COTTON.

What has been said about environment for Caravonica cotton is also in the main true for Sea Island. This variety probably will not do as well upon the heavier soils as does Caravonica or as it will upon soils of medium character.

Good location in hot, protected places is important, but the general opinion has been that Sea Island will thrive at higher elevations than will Caravonica. The Station ginned a small shipment that was grown at Honaunau, Hawaii, and found it to be of excellent quality. However, the higher yields with Sea Island are likely to be from places near sea level, where the maximum temperature aids in the full development of the crop. The director of this Station has said that he never saw such productive Sea Island plants even in the Sea Island belt as he has seen at Waianae, Oahu.

Sea Island is not so likely to prove as drouth resistant as the Caravonica cotton, a medium supply of moisture during its entire growing period being more necessary. However, under dry conditions where moisture has been conserved by timely and frequent cultivation a fair crop is obtainable. The plants must be planted at least five feet by four, and under best conditions five by five, six by four or six by five may be preferable.

PICKINGS.

Sea Island cotton does not require as frequent picking as does Caravonica, since the bolls open but partly and the cotton does not flush out as in Caravonica or in Upland cotton. While this is true in regard to number of pickings, yet the expense of picking is likely to be about the same, because, with the partly open bolls, the cotton is harder to pick and less can be picked in a day (25-50 lbs.). The seed cotton should be well dried before storing. Sea Island cotton must be ginned upon roller gins. It can be ginned slightly faster than Caravonica. By increasing the number of revolutions to 130 per minute, our small gin showed capacity of 22 pounds per hour. Using hand power, with two men turning, 45-50 revolutions only are possible, which gives a capacity of about 8 pounds per hour. The increased cost of ginning is self-evident.

It is hardly to be hoped that Hawaii will compete with the

Sea Island belt in producing the quality of cotton known as Fine or Extra Fine Islands, which grades bring the highest prices of any cottons (30-60¢ per pound). We may not be able to produce the required length of staple, our growers cannot within a score of years acquire the knowledge and experience necessary for the proper handling of the cotton, and furthermore the demand for these grades is now fairly well supplied. However, we can compete for the classes known as "Floridas" and "Georgias," which command prices ranging from 20¢ to 35¢ per pound.

PRUNING.

In pruning Sea Island cotton only low pruning should be practiced, since the new growth comes from buds developed upon the lower trunk or near the base of the vegetative branches. Under wind-free conditions usually no vegetative branches are produced.

Whether Sea Island can be grown profitably as a perennial has yet to be demonstrated. It was originally a perennial plant, but grew larger than the present improved type, while producing less and greatly inferior staple. It would seem from the trials at this Station that the first crop has always been the best. This fact might be due to some factor within the plant itself, but we have observed that in the second year the plants are so badly attacked by insects that their vitality is injured, the bolls become smaller, and many may not mature properly, while in such bolls of course the lint would be greatly reduced in value; and the bollworm particularly has been the cause of the loss of the second crop.

The annual report of this Station for 1910 assigns the failure of the second crop entirely to bollworm. Upon another small plat of Sea Island in 1910 the plants yielded more than one pound of seed cotton each for a first crop; but in 1911 the cotton was so badly attacked by mealy bug that the plants were weakened, and, the bollworm aiding in the destruction, no records were taken. Similarly another new planting, an acre in extent, in 1911 produced a fair crop of 293 pounds of lint; but at this date, March, 1912, the mealy bug and bollworm are both in evidence again.* If now the same result is obtained in 1912 as in

*Since the above was written the infestation in our Sea Island cotton became so great that it was deemed advisable to pull up the plants and plant a new crop. By so doing we hope to extend the time of "no food" for the worm and thus hold them in check until much later in the year.

1910 and 1911, we shall conclude that this variety had best be grown as an annual. This may be also the solution of the boll-worm problem, as has been mentioned elsewhere.

YIELDS.

At different times and from various places, but upon small areas only, good yields of this variety have been reported. Even as high as 700 pounds of lint per acre are recorded, but such yields cannot be expected upon a field scale. Upon Maui, at 700 feet elevation, in 1911 a yield of 160 pounds of lint per acre was reported upon a four-acre field. It is doubtful if such a low yield will be profitable.

TABLE No. IV
Sea Island Cotton. 1 Acre.
1911.

Section	No. of Pickings	No. of Bolls	Pounds Seed Cotton	Average Per Cent Lint	Pounds Lint	Pounds Seed	Average number bolls per pound seed cotton	Average per cent Infested
1	4	31482	193.68	28.6	55.43	137.25	162	6.1
2	4	27510	183.86	28.	51.58	132.28	149	15.8
3	4	33993	195.	28.8	56.28	138.72	174	15.9
4	4	45566	283.62	29.7	84.34	199.25	160	22.8
5	4	27005	159.5	28.	44.75	114.75	169	* 25.4
Total					292.38			

* At the beginning of each picking the percentage of infestation was low; i. e. in Section 1.

With plenty of bollworm present, as shown in Table IV, and at 250 feet elevation, an acre upon the Station grounds produced 293 pounds of lint, as given above. These are the only figures available from fields of an acre or more in extent. However, as there are many locations more suited to the crop than those herein given, such as Waianae, Oahu, or Kona, Hawaii, better yields surely are obtainable.

COTTON AS AN ANNUAL OR AS A PERENNIAL.

Whether to grow cotton as an annual or a perennial is a question to be answered only with knowledge of the conditions of the

locality under consideration. Caravonica cotton, all experiments demonstrate, increases its productiveness in later years over that of the first, so that in locations best adapted to Caravonica one should grow it as a perennial.

The difficulties in producing annual cotton are mostly included in the statement "hard to secure a stand." Lack of moisture for germination and attacks of cutworms are the principal causes for lack of stand, but later in the season the lack of moisture might result in diminution of yield. Annual plants, not being so deeply rooted as older plants, would suffer more from extreme drouth than would perennials. So that where extremely dry conditions prevail and water cannot be had, difficulty in securing a stand and reduced yield in first year would indicate that cotton as a perennial is preferable.

On the other hand, where there is a pronounced rainy season annually and a stand is easily secured, an annual cotton may be better. Under these conditions it may be possible, by deep, thorough preparation of soil and thorough surface cultivation, to retain in the soil sufficient moisture for the maturing of the crop.

Furthermore, as a means of controlling the bollworm the growing of annual cotton has decided advantages over the other practice. Under this plan and under our conditions, where cotton is best planted in February or March and where it is all harvested by November 1st or earlier (depending upon variety), by completely destroying all plants in November the bollworm is absolutely without squares, blooms or bolls for food until in May following when the new crop begins to bloom. Under the dry conditions of the winter of 1911-12, upon plants cut back December 1, 1911, blooms appeared February 10th and plenty of worms were found by February 19th, so that, although this may be an extreme case, an interval of absence of worm of only ten weeks was secured. An interval of sixteen to twenty weeks before new blooms appear would be much better, although at that, infestation from ornamental plants in Honolulu would be possible here.

As noted in another place, Sea Island cotton seems to thrive better as an annual. Upland and Egyptian varieties have usually been grown as annuals, and further experiments are necessary to determine whether or not they would be more satisfactory as perennials. Prunings from perennial plants should be destroyed.

Annual plants should be burned or turned under deeply at the close of bearing season.

HANDLING THE CROP.

To secure the highest market price for cotton considerable care is necessary in handling the crop. In the first place, pick only from fully opened bolls, as the cotton in partly opened bolls is still immature, and cotton that is immature shows a large percentage of waste when worked up in the mills. Pick at such intervals as will allow little or none of the cotton to fall to the ground, as such cotton will be more or less discolored and will pick up a quantity of dirt with it. Stained cotton, leaves, dirt or foreign matter of any kind lower the grade of the cotton. Keep out the leaves and dirt and put stained and worm-eaten cotton in separate bags. Stained cotton can be sold readily at the mattress factories in Honolulu, and it will profit the grower to accept a medium price for such cotton here, rather than to include it in his bale and lose possibly a cent per pound upon the bale because of it. Dry seed cotton before storing; otherwise it might heat and damage the staple. Also see that it has not reabsorbed too much moisture again at ginning time. This would happen only during a wet spell of weather or in regions continually damp.

When these precautions have been well observed and the cotton well packed in bales of 300 to 500 pounds, the grower has a right to expect a good price for his cotton.

The cotton that is sent out from Hawaii will have to be gotten down to a better degree of uniformity and guaranteed if the best prices are to be realized and a demand created for the Hawaiian product. In the Sea Island belt, for instance, many of the growers put out such a uniform staple, clean and correct in every particular, that their name upon the bale is a sufficient guarantee as to its contents. Furthermore, they usually put their early and later pickings in separate bales; they sort the seed cotton before ginning, and pick out the "nep" or knots and any yellow cotton that may have passed through the gin. For this trouble they are paid several cents a pound above usual market price. Similarly, many mills prefer Egyptian to home-grown long staple, since the former has been hand sorted and the waste is usually several per cent less. In order to make a name for Hawaiian cotton most of these precautions should be rigidly observed.

IMPROVING THE CROP.

The preliminary step in improvement is to prevent deterioration. Grow but one variety in the same field. Cotton is easily cross-pollinated, and insects, especially bees, carry pollen from one variety to another, even when these are separated by considerable distance. Upon the Station grounds it has been almost impossible to maintain a pure variety, because it has been necessary to try so many kinds, but where cotton is to be improved every effort should be made to prevent accidental crossing. With annual cottons especially, deterioration from this source might be very rapid. Upon the other hand, where cross-pollination does not occur, the annual cottons are subject to more rapid improvement by judicious seed selection. Another important thing to do is to pull up all inferior plants, and especially those producing short, uneven lint or naked seeds. Also destroy any plants which show themselves to be of a different variety from that supposed to have been planted. Many hybrids may be recognized early by their different habit of growth or by leaves; others by character of flowers.

SEED.

Seed should always be selected, since there is always such a great variation in plants, and only by seed selection can the seed be obtained from those varying for the better. Select from plants having a long, uniform staple; high per cent in lint; and prolific habit. These should be the prime requisites, although shape and size of plant or leaf, character of seed, earliness and other qualifications might be considered. If it is impossible to select enough seed for immediate needs simply plant the selected seed in the field in a given place each time and from this place make further selections; but use the balance of seed in planting the main field and within a few years a great improvement will be noted.

Although good cultivation and proper conditions of plant food and moisture do much to maintain quality and yield, a real improvement in a variety must be made through the seed, either by selection alone or by crossing, with selection.

With perennial cotton, results can not be obtained so quickly for apparent reasons, and yet for ultimate improvement the same method must be followed and the same precautions observed. With Caravonica cotton which has been much decried because

of its lack of uniformity, a more uniform product may be obtained by vegetative production; i. e., by buds or cuttings.

CUTTINGS.

Cuttings may be made from the branches of the cotton plants, rooted in the sand bed, and the young plants transplanted to the field. If cuttings are made from only those plants that are uniform in the essential requirements, then the crop which is picked from such plants will be greatly improved in uniformity over the crop from plants grown from seed. Practical uniformity would be secured by taking cuttings at the start from only one plant, but a longer period would be necessary in which to secure plants for a given area. Theoretically this is the plan to follow. Practically, however, there are objections to it. From experience here it seems to be very difficult to root the cuttings and a large per cent perish before rooting and secondly, such plants seem to be less vigorous and productive than plants grown from seed, although, being a perennial, this effect would be less noticeable probably in later years. To properly root cuttings, bottom heat which can be secured only in hot beds or green houses, is necessary, and possibly where such conditions are obtainable better rooted and more vigorous plants could be secured.

BUDS.

Mr. E. C. Smith was the first to attempt budding Caravonica and is authority for the statement that were he to plant 100 acres he would bud every plant. By taking buds only from plants uniform in every way, or as stated for cuttings, taking them from only one plant, good results will be quickly secured.

Budding should be done when the plant is young, when the bark slips easily and with dormant buds if possible. Under the best of conditions a large number of failures are to be expected.

(See Annual Report, 1909. Also Bulletin No. 20 for method of budding.)

IRRIGATION.

Where rainfall is very light and likely to be uncertain at critical times, a moderate supply of water for irrigating purposes will be found very beneficial. Although cotton requires less water than our other crops here except pineapples a certain amount is necessary to germinate the seed, to produce a plant of proper size and to insure the proper development of the bolls.

• Egyptian cotton has been grown under irrigation more than the other varieties and it is the one upon which the U. S. Department of Agriculture is now conducting experiments under irrigation in Yuma, Arizona, and in California. It is claimed to be less drouth resistant than upland cotton and necessarily then, less so than Caravonica.

While we are conducting no experiments with cotton under irrigation yet from a study of practices elsewhere a few suggestions may be taken. Irrigations should be thorough and should be followed by most thorough cultivation. Do not replace cultivation with irrigation. The first application should be before planting unless the soil is sufficiently moist. This hastens germination and aids in securing the proper stand. Then withhold water and cultivate for several weeks—a month at least—and allow plants to root well and deeply. The number of irrigations will depend upon variety, nature of soil, amount and distribution of rainfall and these conditions vary so within short distances that no exact number can be given. In general it can be said that unless rains occur within six or eight weeks after planting, another irrigation should be given and after that only a small amount of moisture will be needed if proper cultivation is kept up.

A good growth of plant should be secured before any squares are formed and when fruiting begins a slower, steady growth is desirable.

As mentioned in another paragraph Caravonica will not prove as shy in bearing in first year if sufficient water is supplied and also, as stated, the fruiting will be continuous until fall if moderate supply of moisture is obtainable during summer months. Water should be withheld to check vegetative growth and give opportunity for fruiting and also to allow the plant to become dormant before pruning.

If growing Caravonica for two crops annually one watering is necessary before seeding or after pruning and according to conditions another may or may not be necessary during the fruiting season, but if necessary the application should not be excessive.

When an annual pruning only is given, this should be done before the rainy season. When rains are not sufficient to make a good growth of the plant, irrigation should be resorted to and as in the former case, repeat if necessary.

DISEASES AND INSECTS.

A fungus disease of some kind has been noticed upon cotton at Kaneohe and at Pupukea, Oahu. It attacks the bolls, preventing proper maturing and opening. As high as ten per cent of the bolls at some pickings were found to be worthless, the percentage being larger during wet spells. The disease is probably antracnose although the discolored spots characteristic of this fungus were not always present.

The insects attacking cotton in Hawaii have been described in Bulletin No. 18 of this Station. Press Bulletin No. 32 gives the results in 1911 of cultural methods of controlling the boll worm. Tables I, II and IV give in one column the percentages of infestation in our fields upon different dates. It should be added here, however, that only where frequent pickings are made will such good results as shown in these tables, be obtained.

FERTILIZERS AND ROTATION.

Cotton has been found to respond readily to a judicious use of fertilizers. Where it is grown continuously upon the same land and given the clean cultivation which it demands, there will result a gradual diminution of the humus in the soil and also a reduction of the supply of available plant food. Rotation of crops and the plowing under of organic manures in some form will be found necessary in order to keep up the soil fertility. A further addition of commercial fertilizers will materially increase the yield. Nitrogenous manures should be used sparingly since they tend to increase the formation of wood and delay maturing, and cotton plants here seem to acquire sufficient size. Larger amounts of potash or of acid phosphate may be used especially of the latter since it increases fruitfulness and hastens maturity. Fertilizers analyzing 9 per cent of available phosphoric acid, 2 per cent of potash, and 2 per cent of nitrogen, in amounts varying from two hundred to six hundred pounds an acre, are used largely in the South. The proper proportions and amounts have not been determined for cotton in Hawaii.

The fertilizer should be applied before planting and with perennial cotton any later application can be placed in furrows made close to the plants upon each side of the rows and then covered with cultivators or hoes. Fertilizer distributors are used for such work in the South and are very economical implements since they cost only about \$5 each.

For rotation crops, Jack beans, soy beans, cowpeas, or other legumes are preferable although grain or other crops may be grown.

CONCLUSION AND SUMMARY.

Cotton culture in some parts of Hawaii has been abandoned.

In some locations this result was brought about because of the damage done by the bollworm; in other regions, because they had conditions ill suited to the best growth of the crop.

A good quality of cotton in paying quantities can be produced under certain conditions.

On the lower elevations; with a moderate supply of moisture; with absence of, or protection from, wind; with a good supply of heat; and in fields that can be given horse cultivation—a good profit can be made in growing cotton even under bollworm conditions.

Because of the bollworm, Sea Island cotton should be grown as an annual, and also only where there is no difficulty in securing a stand.

In drier locations, Caravonica will likely be the better variety and should be grown only as a perennial. Good yields will be obtained from this variety in the first year only where the very best conditions of heat and moisture exist. It requires an occasional pruning, which should be given usually prior to the rainy season. Under certain conditions, two prunings can be given and two crops obtained, and where this is possible greater immunity from the bollworm will result.

Careful handling of the staple is necessary at all times.

A more uniform product can be secured by propagating with buds or cuttings, but only through the seeds is any improvement possible. To secure this, hybridization must be prevented or controlled; all inferior plants or those having undesirable qualities must be destroyed; and seed must be selected only from those which have desirable characters.

In determining what is suitable environment for cotton in the Islands we find that location evidently has far more influence than the character of the soil. Any soil will grow cotton (some, however, require fertilization, and in some perhaps the water might be too brackish), but *some locations preclude any possible chance of profit.*

